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FORAGE FISH MONITORING PROGRAM

1984 AND 1985

D.J. MUNRO

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ABSTRACT

A forage fish monitoring program was initiated on a trial basis in 1984 by the Water Quality Branch of Environment Canada. In the Western and Northern Region, forage fish were collected at a number of the Region's water quality monitoring stations in 1984 and 1985. The goals of this activitity were to evaluate forage fish as a biological monitoring tool for assessing the bioaccumulation of pollutants in the Western and Northern Region and to begin compilation of a data base related to forage fish. Nineteen samples were collected at fourteen sites and analyzed for metals and organochlorine compounds. The data and preliminary discussion of the results are presented in this report. Forage fish were found to be a useful tool showing the presence of a number of organic compound which are not typically found in routine water samples. Wide variation was found in metal concentrations between various sites and fish species suggesting possible differences in accumulation rates between species and availability of some metals. However, further work is required to assess the significance of these differences.

RESUME

Un programme de surveillance du poisson alimentaire a été entrepris en 1984 à titre expérimental par la Division de la qualité des eaux d'Environnement Canada. Dans la région de l'Ouest et du Nord, on a recueilli, en 1984 et 1985, du poisson alimentaire à un certain nombre de stations de contrôle de la qualité de l'eau. L'activité visait à évaluer la valeur du poisson alimentaire comme outil de surveillance biologique pour déterminer la bioaccumulation de polluants dans la région de l'Ouest et du Nord et à entreprendre la compilation d'une base de données sur le poisson alimentaire. Dix-neuf (19) échantillons ont été prélevés à quatorze (14) stations et ont été analysés pour voir s'il y avait présence de métaux et de composés organochlorés. Les données et les analyses préliminaires des résultats sont livrées dans ce rapport. On a estimé que le poisson alimentaire était utile pour déterminer la présence d'un certain nombre de composés organiques que l'on ne peut déceler, de facon générale, en procédant à des prélévements systématiques d'eau. Les concentrations de métal diffèrent grandement selon les points de prélèvements et les espèces de poisson; on peut donc en déduire que les taux d'accumulation varient chez les espèces et selon la présence de certains métaux. Toutefois, il faut poursuivre les recherches pour établir l'importance des différences.

TABLE OF CONTENTS

		PAGE
ABSTRACT		i
RESUME		ii
LIST OF TABLES		iv
1.0	INTRODUCTION	1
2.0	METHODS	2
3.0	RESULTS AND DISCUSSION	4
3.1	Metals	6
3.2	Organics	11
4.0	CONCLUSIONS AND RECOMMENDATIONS	12
REFERENCES		13
APPENDIX A	FORAGE FISH SPECIES LIST	15

LIST OF TABLES

NUMBER		PAGE
1	Forage Fish Collection Sites.	3
2	Detection Levels for Organic Compounds (ng/g).	5
3	Physical Data and Metal Results in ug/g Wet Weight for Forage Fish Samples.	7
4	Physical Data for Forage Fish Samples Analyzed for Organic Compounds.	8
5	Positive Detections of Organic Compounds (ng/g Wet Weight).	9

1.0 INTRODUCTION

In September 1983, the Water Quality Branch decided at a national meeting of Branch biologists to initate a forage fish monitoring program to assess the bioaccumulation of pollutants in the aquatic environment. The program was to be on a trial basis and each region agreed to conduct some form of forage fish monitoring.

Interest in the use of forage fish arose as a result of work conducted in the Great Lakes by Suns and Rees (1978) and Suns et al. (1981; 1983; 1985) as well as the desire to gain a better understanding of the significance of the levels of contaminants found in routine water samples. Suns used observations of bioaccumulation, in young-of-the-year spottail shiners (Notropis hudsonius) to demonstrate the presence of organochlorines in the near shore waters for various locations on the Great Lakes. Suns chose spottail shiners because they represented a homogeneous sample from a single age group, facilitating sample standardization for station-to-station comparability and point-source investigation. By using young-of-the-year spottail shiners, recent contaminant loading could be evaluated. Other advantages of the spottail shiner include the ease of collection, identification and their widespread distribution in the Great Lakes.

The Water Quality Branch realized that a national forage fish program based solely on spottail shiners was not possible as they are not indigenous throughout Canada (Scott and

Crossman, 1973). Therefore, it was decided that an abundant species from each site would be used for analysis, with a concerted attempt made to analyze as few different species as possible.

In the Western and Northern Region, forage fish were collected at a number of the Region's routine water quality monitoring stations in 1984 and 1985. The goals of this study were: to evaluate forage fish as a biological monitoring tool for use in the Western and Northern Region; and to begin compilation of a data base related to forage fish. The data and preliminary discussion of the results of this project are presented here.

2.0 METHODS

Forage fish were collected by beach seine at ten sites in August of 1984 and at four sites in September of 1985 (Table 1). Ten of these sites coincide with routine water quality monitoring sites, the four other sites coincide with sites extensively sampled as part of a special study conducted on the South Saskatchewan River and Lake Diefenbaker. Triplicate samples were collected at one site in each year, Souris River in 1984 and Saskatchewan River in 1985 and both river and emerald shiners were taken for analysis from the Qu'Appelle River in 1985.

Immediately after collection, the fish were sorted by species and size. Samples for chemical analysis, made up of

Table 1. Forage Fish Collection Sites.

Site	NAQUADAT Station Number
Battle River near Unwin	00SA05FE0001
Beaver River at Beaver Crossing	00AL06AD0001
North Saskatchewan River at Lea Park	00AL05EF0001
Red Deer River at Bindloss	00AL05CK0001
South Saskatchewan River at Hwy 41	00AL05AK0001
South Saskatchewan River near Leader	00SA05HB0002
South Saskatchewan River near Lemsford	00SA05HB0001
Lake Diefenbaker at Saskatchewan Landing	N/A
Lake Diefenbaker at Riverhurst	N/A
Souris River near Glen Ewen	00SA05ND0001
Saskatchewan River Above Carrot River	00MA05KH0001
Carrot River at Turnberry	00SA05KH0002
Red Deer River Near Erwood	00SA05LC0001
Qu'Appelle River near Welby	00SA05JM0014

organisms of approximately equal size, were then taken from the dominant species in the catch. In order to obtain sufficent sample for analysis, samples consisted of from two to 30 fish, depending on the size of the fish. Samples for metal and organic analysis were placed in polyethylene bags and solvent washed aluminum foil, respectively. Samples were frozen on dry ice in the field and remained frozen (minus 20 degrees) until analyzed. Specimens of all the fish species collected were preserved in formalin for confirmation of identification and development of a species list for each site. Identification was done using the keys from Scott and Crossman (1973).

Chemical analyses was performed at the Water Quality Branch National Laboratory in Burlington using analytical methods, as decribed in the Analytical Methods Manual (Water Quality Branch, 1981). Five samples, for organic analysis, also underwent additional cleanup to enhance the detection levels (Table 2), using a carbon fibre cleanup (Afghan and Wilkinson, 1984). These five samples were then re-analyzed for organochlorines and also analyzed for chlorophenols following the methods decribed by Lee et al., (1984).

3.0 RESULTS AND DISCUSSION

A total of 23 different fish species were collected at the 14 sites. Species lists for each site are presented in Appendix A. Five different fish species were taken for analysis: river and emerald shiners, white sucker, yellow perch and black

Table 2. Detection Levels for Organic Compounds (ng/g).

Compound	Routine Detection Level	Enhanced Detection Level
Hexachlorbenzenes	4.0	0.4
Alpha-BHC	4.0	0.4
Gamma-BHC	4.0	0.4
Heptachlor epoxide	4.0	0.4
Heptachlor	4.0	0.4
Aldrin	4.0	0.4
Gamma-cis Chlordane	4.0	0.4
Gamma-trans Chlordane	4.0	0.4
Dieldrin	4.0	0.4
Alpha-Endosulfan	4.0	0.4
Beta-Endosulfan	4.0	0.4
p,p-DDT	4.0	0.4
p,p-DDE	4.0	0.4
p,p'-DDD	4.0	0.4
o,p-DDT	4.0	0.4
Mirex	4.0	0.4
p,p-Methoxychlor	4.0	0.4
Arochlor (Total PCB's)	90.0	9.0
Chlorophenols *		2.5

* Chlorophenols checked - 2,4,5 Tri, 2,4,6 Tri, 2,3,4,6 Tetra, and Penta

bullhead. The physical data for the fish included in each sample and the metal and organic results are found in Tables 3, 4 and 5.

3.1 Metals

The metal results (Table 3) show considerable variability between sampling sites. Chromium, copper and nickel concentrations were higher in white sucker samples from the Battle, Beaver and North Saskatchewan Rivers than in fish from the other rivers. The higher metal concentrations may be a function of the difference in accummulation rates and/or feeding habits of young white suckers relative the other species sampled rather than a reflection of a greater presence of the metals. Analyses of white suckers samples was undertaken only from these three sites. Chromium, copper and nickel do not typically have high bioconcentration factors in fish, ranging from 40 to 200 (Chapman et al., 1968). The routine water quality monitoring data for these sites show the concentration of these metals in the water were low during the summer of 1984. Based on the mean metal concentrations of the four monthly water samples from each site collected from May through August of 1984, the bioconcentration factors for copper and chromium were in the order of 400 to 800, substantially higher than those reported in the literature. These elevated metal levels may reflect the bottom feeding habit of young sucker and sediment and other food in the gut of the white suckers may have contributed to the elevated metal levels.

Table 3. Physical Data and Metal Results in ug/g Wet Weight for Forage Fish Samples.

Site	Date	Species	Number of Fish	Total Weight (g)	Fork Length Range (mm)	Cd	Cr	Cu	Ni	Pb	Zn	Hg	As	Se
Battle River near Unuin	07-Aug-84	W. Sucker	11	26.5	52-63	<0.02	0.86	2.0	0.31	<0.10	30.	0.05	0.10	0.29
Beaver River at Beaver Crossing	08-Aug-84	W. Sucker	27	22.5	36-42	0.04	0.55	1.5	0.24	<0.10	30.	0.03	0.20	0.21
W. Saskatchewan River at Lea Park	08-Aug-84	W. Sucker	11	23.5	50-64	0.03	0.44	1.6	0.25	<0.10	20.	0.06	0.08	0.33
Red Deer River at Bindloss	14-Aug-84	R. Shiner	15	23.5	52-72	0.04	0.29	0.79	0.10	<0.10	50.	0.09	<0.05	0.86
S. Saskatchewan River at Hwy 41	14-Aug-84	E. Shiner	4	27	91-99	0.02	<0.20	1.1	0.08	<0.10	40.	0.17	<0.05	0.96
S. Saskatchewan River at Leader	13-Aug-84	R. Shiner	5	13	63-65							0.10	0.09	0.88
S. Saskatchewan River near Lemsford	15-Aug-84	E. Shiner	8	26	80-86	<0.02	0.22	0.65	<0.05	<0.10	40.	0.10	0.05	1.0
Lake Diefenbaker at Sask. Landing	15-Aug-84	E. Shiner	8	24	75-80	<0.02	0.21	0.51	<0.05	<0.10	40.	0.07	0.10	0.86
Lake Diefenbaker at Riverhurst	16-Aug-84	Y. Perch	16	23.5	49-58	0.02	0.29	0.79	0.10	<0.10	20.	0.06	0.10	0.41
Souris River near Glen Ewen	26-Sep-84	B. Bullhead	3	11	63-67							0.10	0.08	0.44
Souris River near Glen Ewen	26-Sep-84	B. Bullhead	4	13	56-60	<0.02				<0.10	28.1	0.09	0.11	0.44
Souris River near Glen Ewen	26-Sep-84	B. Bullhead	4	12	54-56							0.08	0.10	0.41
Saskatchewan R. Above Carrot River	17-Sep-85	E. Shiner	20	30	54-63	0.02	<0.20	0.87	0.13	<0.10	60.	0.04	0.11	0.44
Saskatchewan R. Above Carrot River	17-Sep-85	E. Shiner	20	33	50-66	<0.02	0.22	0.85	0.14	<0.10	60.	0.04	0.11	0.45
Saskatchewan R. Above Carrot River	17-Sep-85	E. Shiner	20	29	57-60	0.02	0.28	1.0	0.12	<0.10	50.	0.03	0.10	0.45
Carrot River at Turnberry	17-Sep-85	E. Shiner	15	25	56-67	<0.02	<0.20	0.89	0.07	<0.10	50.	0.04	0.15	0.49
Red Deer River Near Erwood	17-Sep-85	R. Shiner	25	37	38-58	<0.02	0.35	0.93	0.37	0.10	70.	0.07	0.16	0.91
Qu'Appelle River near Welby	18-Sep-85	R. Shiner	25	34	44-57	<0.02	0.72	0.94	0.39	<0.10	60.	0.04	0.25	0.58
Qu'Appelle River near Welby	18-Sep-85	E. Shiner	30	39	42-66	<0.02	0.44	0.94	0.22	<0.10	50.	0.04	0.13	0.54

Table 4. Physical Data for Forage Fish Samples Analyzed for Organic Compounds.

	Site	Date	Species	Number of Fish	Total Weight(g)	Fork Length Range(mm)
*	Battle River near Unwin	07-Aug-84	W. Sucker	4	15	60-72
*	Beaver River at Beaver Crossing	08-Aug-84	W. Sucker	8	12	47-53
*	N. Saskatchewan River at Lea Park	08-Aug-84	W. Sucker	5	12	60-65
*	Red Deer River at Bindloss	14-Aug-84	R. Shiner	4	13.5	72-84
*	S. Saskatchewan River at Hwy 41	14-Aug-84	E. Shiner	2	12	91-95
	S. Saskatchewan River at Leader	13-Aug-84	R. Shiner	7	11	57-59
	S. Saskatchewan River near Lemsford	15-Aug-84	E. Shiner	4	17	84-93
	Lake Diefenbaker at Sask. Landing	15-Aug-84	E. Shiner	3	11.5	82-85
	Lake Diefenbaker at Riverhurst	16-Aug-84	Y. Perch	6	13	57-69
	Souris River near Glen Ewen	28-Sep-84	B. Bullhead	4	12	53-62
	Souris River near Glen Ewen	28-Sep-84	B. Bullhead	5	11	52-55
	Souris River near Glen Ewen	28-Sep-84	B. Bullhead	5	14	58-62
	Saskatchewan River Above Carrot River	17-Sep-85	E. Shiner	25	34.8	48-58
	Saskatchewan River Above Carrot River	17-Sep-85	E. Shiner	20	30.4	53-62
	Saskatchewan River Above Carrot River	17-Sep-85	E. Shiner	25	34.2	48-62
	Carrot River at Turnberry	17-Sep-85	E. Shiner	20	36	58-70
	Red Deer River Near Erwood	17-Sep-85	R. Shiner	25	36	43-65
	Qu'Appelle River near Welby	18-Sep-85	R. Shiner	25	31	41-56
	Qu'Appelle River near Welby	18-Sep-85	E. Shiner	30	40	43-67

* - samples under went additional cleanup to enhance detection levels following initial cleanup and analysis

Table 5. Positive Detections of Organic Compounds (ng/g Wet Weight).

Site	Alpha-BHC	p',p'-DDE	p',p'-DDT	p',p'-DDD	Total PCB	Dieldrin	Alpha-Chlordane
Battle River near Unwin			7.		300.		
Beaver River at Beaver Crossing		* 6.	2.	4.	390.	1.5	0.5
N. Saskatchewan River at Lea Park			3.		140.		
Red Deer River at Bindloss			2.		130.		
S. Saskatchewan River at Hwy 41			1.		30.		
Lake Diefenbaker at Sask. Landing	* 9.						
Carrot River at Turnberry	* 5.						

* - detection found in samples with routine cleanup all other positive results found following enhanced cleanup to lower the detection levels.

Selenium concentrations were higher in samples from the South Saskatchewan River system and the Red Deer River near Erwood (0.86 to 1.0 ug/g) than at other sites (0.21 to 0.58 ug/g). Routine water quality monitoring conducted on these rivers throughout the summer months prior to the fish collection show low levels of dissolved selenium in the water (0.1 to 0.7 ug/L). This suggests bioconcentration factors in the order of 2000, substantially higher than those reported by United States Environmental Protection Agency (1980). However, the Environmental Protection Agency bioconcentation factors are based on levels of total selenium in the water rather than the dissolved form and are not directly comparable. The higher levels of selenium in these fish samples are all below the 3.0 ug/g level recommended for aquatic biota by the International Joint Commission (1981) to protect predatory fish and mammals.

The difficulty in comparing metal levels in different fish species is seen in the results of river and emerald shiner samples from the Qu'Appelle River. The river shiner sample has substantially higher levels of chromium, nickel and arsenic than the emerald shiner sample. This difference and the question raised earlier about the white sucker samples point out the need to use as few fish species as possible in order to allow comparison between sites and to use the same species at a particular site if temporal trends are to be examined.

3.2 Organics

The majority of samples for organic compound analysis had levels below the analytical detection levels (Table 2); the positive detections are reported in Table 5. Only three samples had detectable concentrations of BHC and DDE at the routine detection level. The five samples which underwent carbon fibre cleanup all had positive levels of PCBs and DDT at the lower detection level. Dieldrin, chlordane and DDD were also found in the white sucker sample from Beaver River. As seen in the metal concentrations, the white sucker samples had higher levels of PCB's. The Battle and Beaver Rivers samples in particular had PCB concentrations of 300 and 390 ng/g, respectively. The white sucker sample from the North Saskatchewan had a lower PCB concentration (140 ng/g) which was comparable to the river shiner sample from the Red Deer River (130 ng/g) but substantially higher than the emerald shiner sample from the South Saskatchewan River (30 ng/g). As was suggested in the discussion of the metal results, these higher concentrations in the white sucker samples may be a function of the difference in feeding habit and/or accumulation rates in white suckers, relative to other species, rather than greater presence of these contaminants in the Beaver and Battle Rivers. It should be noted that four samples had PCB concentrations greater than the concentration (100 ng/g) recommended by the International Joint Commission (1975) for protection of fish-consuming birds and mammals.

4.0 CONCLUSIONS AND RECOMMENDATIONS

The use of forage fish to examine the presence of metal and organic compounds has been shown to be a useful tool. A number of organic compounds have been found which are not found in the routine water quality monitoring program. Metal concentrations in forage fish have been shown to vary widely between location and fish species. This variation requires further study, however, it does suggest the possibility of differences in the availability of some metals at the sites examined, most notably selenium. It is recommended, based on this initial examination of forage fish in the Western and Northern Region, that forage fish surveys be repeated in the future. The program should re-examine sites already sampled and expand to additional routine water quality monitoring sites. A concerted effort should be made to maintain the same species for analysis as were initially analyzed at each site and if possible reduce the number of species analyzed to two or three species by exerting greater effort to collect target species. Collection and analysis of more than one target species per site should be done where possible in order to allow comparison of contaminant levels between target species. Through the continuation of forage fish surveys the value of these initial survey results will be further realized as these data are compared with future data.

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APPENDIX A

FORAGE FISH SPECIES LIST

Table 1. Forage Fish Species List at Each Site.

Beaver River at Beaver Crossing - sampled August 8, 1984

White Sucker (*Catostomus commersoni*)
Spottail Shiner (*Notropis hudsonius*)
Pearl Dace (*Semotilus margarita*)
Brook Stickleback (*Culaea incontans*)

North Saskatchewan River at Leapark - sampled August 8, 1984

White Sucker (*Catostomus commersoni*)
Spottail Shiner (*Notropis hudsonius*)
River Shiner (*Notropis blennius*)
Emerald Shiner (*Notropis atherinoides*)

Battle River near Unwin - sampled August 7, 1984

White Sucker (*Catostomus commersoni*)
Trout-perch (*Percopsis omiscomaycus*)
Pearl Dace (*Semotilus margarita*)
Longnose Dace (*Rhinichthys cataractae*)

Red Deer River near Bindloss - sampled August 14, 1984

River Shiner (*Notropis blennius*)
Emerald Shiner (*Notropis atherinoides*)
Longnose Dace (*Rhinichthys cataractae*)
Goldeye (*Hiodon alosoides*)

South Saskatchewan River at Highway 41 - sampled 14, 1984

River Shiner (*Notropis blennius*)
Emerald Shiner (*Notropis atherinoides*)
White Sucker (*Catostomus commersoni*)
Trout-perch (*Percopsis omiscomaycus*)
Longnose Dace (*Rhinichthys cataractae*)
Quillback (*Carpiodes cyprinus*)

South Saskatchewan River at Leader - sampled August 13, 1984

River Shiner (*Notropis blennius*)
Emerald Shiner (*Notropis atherinoides*)
White Sucker (*Catostomus commersoni*)
Goldeye (*Hiodon alosoides*)
Yellow Perch (*Perca flavescens*)

Table 1.Forage Fish Species List at Each Site (cont'd).

South Saskatchewan River near Lemsford - sampled August 15, 1984

Emerald Shiner (Notropis atherinoides)
Spottail Shiner (Notropis hudsonius)
Goldeye (Hiodon alosoides)

Lake Diefenbaker at Saskatchewan Landing - sampled August 15, 1984

Emerald Shiner (Notropis atherinoides)
Spottail Shiner (Notropis hudsonius)
Goldeye (Hiodon alosoides)
White Sucker (Catostomus commersoni)
Walleye (Stizostedion vitreum)

Lake Diefenbaker at Riverhurst Ferry - sampled August 16, 1984

Yellow Perch (Perca flavescens)
Emerald Shiner (Notropis atherinoides)
River Shiner (Notropis blennius)
White Sucker (Catostomus commersoni)
Trout-perch (Percopsis omiscomaycus)

Souris River near Glen Ewen - sampled September 28, 1984

Black Bullhead (Ictalurus melas)
River Shiner (Notropis blennius)
Blackside Darter (Percina maculata)

Saskatchewan River above Carrot River - sampled September 17, 1985

Emerald Shiner (Notropis atherinoides)
Spottail Shiner (Notropis hudsonius)

Carrot River at Turnberry - sampled September 17, 1985

Emerald Shiner (Notropis atherinoides)
Spottail Shiner (Notropis hudsonius)
River Shiner (Notropis blennius)
Trout-perch (Percopsis omiscomaycus)
Yellow Perch (Perca flavescens)
Longnose Sucker (Catostomus catostomus)

Table 1.Forage Fish Species List at Each Site (cont'd).

Red Deer River near Erwood - sampled September 17, 1985

River Shiner (Notropis blennius)
White Sucker (Catostomus commersoni)
Brook Stickleback (Culaea incontans)
River Darter (Percina shumardi)
Johnny Darter (Etheostoma nigrum)
Logperch (Percina caprodes)
Blacknose Dace (Rhinichthys atratulus)

Qu'Appelle River near Welby - sampled September 18, 1985

River Shiner (Notropis blennius)
Emerald Shiner (Notropis atherinoides)
Spottail Shiner (Notropis hudsonius)
Trout-perch (Percopsis omiscomaycus)
White Sucker (Catostomus commersoni)
Brook Stickleback (Culaea incontans)
Carp (Cyprinus carpio)
Rock Bass (Ambloplites rupestris)